

MICROSTRUCTURES OF HIBONITE FROM AN ALH A77307 (CO3.0) CAI: EVIDENCE FOR EVAPORATIVE LOSS OF CALCIUM. Jangmi Han^{1,2}, Adrian J. Brearley³ and Lindsay P. Keller². ¹LPI, 3600 Bay Area Blvd, Houston, TX 77058. E-mail: jangmi.han@nasa.gov. ²Robert M. Walker Laboratory for Space Science, ARES, NASA/JSC, 2101 NASA Pkwy, Houston, TX 77058. ³Department of Earth and Planetary Sciences, MSC03-2040, University of New Mexico, Albuquerque, NM 87131.

Introduction: Hibonite is a comparatively rare, primary phase found in some CAIs from different chondrite groups and is also common in Wark-Lovering rims [1]. Hibonite is predicted to be one of the earliest refractory phases to form by equilibrium condensation from a cooling gas of solar composition [2] and, therefore, can be a potential recorder of very early solar system processes. In this study, we describe the microstructures of hibonite from one CAI in ALH A77307 (CO3.0) using FIB/TEM techniques in order to reconstruct its formational history.

Sample and Methods: A FIB section was extracted from a region consisting of subparallel hibonite laths intergrown with spinel and minor perovskite in hibonite-spinel CAI 03 and was cut normal to the elongation direction of the hibonite laths [3]. The FIB section was investigated by a variety of TEM techniques (BF- and HR-TEM, DF-STEM, EDS and electron diffraction).

Results: The FIB section consists predominantly of hibonite and spinel with minor perovskite and melilite [3]. Hibonite grains (0.2-5 μm long and 60 nm-2.5 μm wide) are elongated along the a axis and subparallel to each other. Most hibonite grains contain abundant planar defects although some are free of defects indicative of a well-ordered structure. Electron diffraction patterns of hibonite show streaking along the c axis, indicative of stack disorder. High-resolution TEM images of hibonite exhibit variations in d spacing of the lattice fringes, suggestive of stacking disorder. For example, isolated layers that are 2.7 nm wide are intergrown with the prominent 2.2 nm wide layers of stoichiometric hibonite. In addition, EDS analyses for hibonite are close to $\text{Ca}(\text{Al},\text{Si},\text{Ti},\text{Mg})_{12}\text{O}_{19}$ in composition, but do show deficiencies in CaO content (7.5-8.8 wt%) where the defects are concentrated.

Discussion: Our TEM observations of hibonite indicate that its structure was disturbed by Ca loss probably due to partial volatilization. The measured d spacing of 2.2 nm corresponds to the c dimension of the ideal hibonite structure, consisting of a sequence of four-closely-packed O layers and Al ions in a spinel block alternating with a Ca-containing layer [4]. In contrast, the observed local presences of the d spacing of 2.7 nm can be interpreted as the result of alteration of the stacking sequence due to the absence of a Ca-containing layer and the presence of a thicker spinel block with six CCP O layers [4]. This interpretation is consistent with the observed CaO deficiency of hibonite. However, previous Mg isotopic studies indicated that most hibonite-bearing CAIs in CO3s have no discernable evidence for evaporative loss [5]. This implies that hibonite experienced extensive loss of less refractory Mg at the time of Ca evaporation and later recondensation of Mg [6].

References: [1] MacPherson G. J. (2014) Treatise on Geochemistry II vol.1 pp.139-179. [2] Ebel D. S. & Grossman L. 2000. *GCA* 64: 339-366. [3] Han J. & Brearley A. J. 2014. Abstract #2125. 45th LPSC. [4] Schmid H. & De Jonghe L. C. 1983. *Philos. Mag. A* 48: 287-297. [5] Russell S. S. et al. 1998. *GCA* 62: 689-714. [6] Simon J. I. & DePaolo D. J. 2010. *EPSL* 289: 457-466.